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Aplicability of respiratory muscle strength as part of the surgical risk scale based on Tonrrington and Henderson scoring system

Aplicabilidade da média das forças musculares respiratórias como parte da escala de risco cirúrgico baseada na escala de Torrington e Henderson

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Abstract

Objective: Evaluate the applicability of mean percentage from the predicted value of respiratory muscle strength (maximal inspiratory pressure-MIP; maximal expiratory pressure-MEP), as (% MIP + % MEP)/2, as well as the peak expiratory flow (% PEF) preoperatively, as part of a surgical risk scale for predicting the risk of postoperative pulmonary complications (PPC). **Methods**: Data on patients undergoing elective surgery of chest, abdomen and limbs were assessed preoperatively using the items and the scoring system proposed by the Torrington and Henderson, and replacing spirometry by the mean values of both (% MIP + % MEP)/2 and % PEF. **Results**: The proposed scale applied to 108 patients with a mean age of 55.2 ± 14.0 presented PPC rate of 37.0% (p = 0.0001), of which 20.0% were classified as high risk (HR), and 62.5% moderate risk (MR). The mean value of respiratory muscle strength showed a statistically significant correlation with PPC (p = 0.000). **Conclusion**: The proposed scale allowed the appropriate stratification of patients at risk for development of PPC. The use of the mean values of (% MIP + % MEP)/2 and % PEF based on the predicted values can be easily applied, making spirometry unnecessary.

Keywords: Postoperative complications. Respiratory muscle. Laparotomy. Thoracotomy.

Resumo

Objetivo*: Avaliar a aplicabilidade da média do percentual do valor predito das forças musculares respiratórias (pressão inspiratória máxima-PI$_{max}$; pressão expiratória máxima-PE$_{max}$), sendo % PI$_{max}$ + % PE$_{max}$/2, e do pico de fluxo expiratório (% PFE) no pré-operatório, como parte de uma escala de risco cirúrgico para predizer o risco de complicação pulmonar pós-operatória (CPP).* **Métodos***: Dados de pacientes submetidos à cirurgia eletiva de tórax, abdômen e membros foram analisados no pré-operatório utilizando os itens e a pontuação proposta pela escala de Torrington e Henderson, e substituindo a espirometria pela média do % PI$_{max}$ + % PE$_{max}$/ 2 e do % PFE.* **Resultados***: Na escala proposta aplicada a 108 pacientes com idade média de 55,2 ± 14,0 a taxa de CPP foi de 37,0% (p = 0,0001), onde 20,0% foram classificados como de alto risco (RA) e 62,5% risco moderado (RM). O percentual da média da força muscular respiratória apresentou uma correlação significante em relação à CPP na escala proposta (p = 0,000).* **Conclusão***: A escala proposta permitiu estratificar de maneira adequada pacientes com risco de CPP. A utilização da média do % PI$_{max}$ + % PE$_{max}$ / 2 e do % PFE, baseados nos valores preditos, podem ser facilmente aplicáveis, tornando-se desnecessária a realização da espirometria.*

Palavras-chave: *Complicações pós-operatórias. Músculos respiratórios. Laparotomia. Toracotomia.*

Introduction

Postoperative pulmonary complications (PPC), especially in abdominal and thoracic surgeries, besides having high rates of morbidity and mortality, extend hospital stay and consequently increase costs to the health care (1).The prevention of PPCs has motivated numerous studies aimed at validating indices to predict surgical risks (2, 3).

The scoring system devised by Torrington and Henderson (4), which used spirometry associated with other risk factors of PPC was validated in 2000 (5). The conclusion was that the scale was able to estimate the probability of PPCs and mortality in three categories: high risk (HR), moderate risk (MR), and low risk (LR). However, spirometry, highly recognized in the 1970s and 80s (6), currently has been more advantageous for patients undergoing pulmonary resection (7) or presenting respiratory symptoms (8).

Some authors found that patients with decreased respiratory muscle strength (MIP and MEP) are at increased risk of developing PPC (9, 10).

Other authors have also suggested the inclusion of MEP in the risk scale proposed for patients undergoing cardiac surgery (11).

The present research suggests that considering the items evaluated as risk factors and the Torrington and Henderson scale, and replacing spirometry by both the predicted values MIP and MEP (% MIP + % MEP)/2, and the predicted peak expiratory flow (% PEF) in the preoperative period, the resulting scores can predict the risk of PPCs in patients undergoing elective surgery of the chest, abdomen and limbs.

Methods

After approval of the present project by the Research Ethics Committee of the Irmandade Santa Casa de Londrina, Parana State, Brazil (CEP 266/07), and after signed the consent form, a cross-sectional study was carried out, quantitative and observational, following the criteria established by the Strengthening the Reporting of Observational Studies in Epidemiology (Strobe) (12).

From October 2007 to February 2009, consecutive patients undergoing surgery with surgical incision in the chest, in abdominal or peripheral wall were evaluated at the Hospital Santa Casa de Londrina (HSCL), Londrina, Parana State, Brazil. Candidates who had some complications leading to emergency surgery, patients undergoing cardiac surgery, and laparoscopic surgery were excluded from the sample.

Of the 147 patients referred for preoperative evaluation, 39 (26.5%) were not included in the study. Of these, 19 did not undergo the surgery proposed by changing the therapeutic approach, five refused to participate in the study, nine were discharged without performing surgery, four patients died in the preoperative stage, and two died during the surgical procedure.

All patients were evaluated by a single observer in the preoperative stage and monitored until hospital discharge or death. The evaluator did not provide patient data for physiotherapists and even for the surgical team. All individuals were attended as routine patients by physiotherapy service at HSCL.

Both the clinical history and physical examination were assessed by a standardized questionnaire, with the following settings: a) high or low thoracic and abdominal surgery referred to surgery with surgical incision in the chest, in abdominal wall, above or below the umbilicus, with intracavitary manipulation, while peripheral referred to the extremity surgery; b) smoker was defined as any individual who had smoked any type or quantity of tobacco for at least six months during the survey (13); c) respiratory symptomatic patient presenting acute or chronic cough and / or expetoration at the time of evaluation (2); d) lung disease referred to the evolution of chronic lung disease, symptomatic, with current treatment or not, and diagnosis previously established (14).

Respiratory muscle strength of the participants was assessed by measuring the maximal inspiratory pressure (MIP) and the maximal expiratory pressure (MEP), using an analog manometer (GERAR®, with scale of -200 to +200 cm H_2O, capsule type sensor and spigot type connection). The examination for collecting data met the international standards established by the American Thoracic Society (2000) (15). To measure the MIP, the patient was asked to perform a forced inspiration from residual volume. For MEP, the subject was instructed to perform a maximal forced expiration from total lung capacity. All maneuvers were maintained for at least two seconds. The values obtained were compared to the table of normality for the Brazilian population (16), and expressed as percentage.

For PEF, a Peak Flow Meter (NCS) was used. The measurement was performed with the patient in sitting position, head erect, mouthpiece between the teeth and on the tongue. The patient was instructed to make a deep breath and then a forced expiration to analyze the expiratory flow (l/ min). The highest value of three consecutive measurements was recorded as technically correct measured value, and additional measurements were performed when the two highest values of three maneuvers presented difference of more than 40 L/min. The values were compared with the predicted values of PEF for adults (17), and expressed as percentage (%PEF).

At the end of the preoperative evaluation, each patient was classified in relation to the risk of developing PPC, according to the classification proposed by the Torrington and Henderson scale (HR – 0 to 3 points, MR – 4 to 6 points, LR – 7 to 11 points), but replacing the spirometry by the mean predicted value of MIP and MEP (% MIP + MEP)/2 and the predicted PEF (% PEF) (4) (Table 1).

In the postoperative period, daily monitoring of each patient was performed during the immediate postoperative period until hospital discharge or occurrence of death. The following definitions were considered as PPC: a) *acute respiratory infection*, patients who had radiological signs of pulmonary consolidation, body temperature > 38 °C, increased number of circulating leukocytes > 25% baseline number; tracheobronchitis was diagnosed with increasing amounts or purulent tracheobronchial secretion by normal chest radiography (18); b) *atelectasis* evidenced by chest radiography and with obvious clinical symptoms of acute respiratory symptom (2); c) *acute respiratory failure*, clinical picture resulting from the exchange pulmonary gas, acutely deficient requiring mechanical ventilation (2); d) *endotracheal intubation or mechanical ventilation for more than 48 hours* for treatment of acute respiratory failure, or need to aspiration of tracheobronchial secretion (2); e) *bronchospasm* characterized by wheezing on auscultation associated with acute respiratory symptoms and the necessity of drug therapy (2).

In patients who died, it was investigated by clinical, laboratory and medical inference data whether the causes were pulmonary origin. The causes of death of pulmonary origin were summarized into two major groups: 1) sepsis after pulmonary infection, when the inflammation was linked to a pulmonary infectious process in which hemodynamic instability emerged, unresponsive to volume replacement, dependence on vasoactive drugs, related to functional failure of at least two major organ systems(19); 2) acute respiratory failure.

Data were tested for normal distribution using the Kolmogorov-Smirnov test. Categorical variables were presented as absolute numbers and proportions, and the continuous variables as mean and standard deviation (± SD). Student's *t* test and Chi-square (X^2) were used to compare the presence or absence of PPC, and Spearman correlation was used

Table 1 - Classification of the risk for PPC, based on the Torrington and Henderson scale (TH) with modifications, replacing spirometry by PEF and manovacuometry

Risk Factors	Points
Age over 65 years	1
Overweight (BMI above 30)	1
Surgical site:	
thoracic	2
abdominal	2
other	1
Pulmonary story:	
current smoker	1
cough and expectoration	1
pulmonary disease	1
Peak expiratory flow (PEF) and manovacuometry:	
PEF <50% predicted	1
% mean predicted value ((MIP + MEP)/2): 65.0 to 74.9%	1
% mean predicted value ((MIP + MEP)/2): 40.0 to 64.9%	2
% mean predicted value ((MIP + MEP)/2): less than 40.0%	3
Classification of risks for complications and mortality	
Points	**Risk**
0 – 3	low
4 – 6	moderate
7 – 11	high

Note: PEF: peak expiratory flow; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure.
Source: Research data.

to correlate the PPC with the risk factors and the proposed scale (rs). Data were analyzed using the Statistical Package for Social Science (SPSS 17.0) at $p < 0.05$ significance level.

Results

One hundred and eight patients were studied, of whom 55 were male (50.9%). The mean age was 56.2 ± 14.0 years with an age range of 19-82 years. Among the patients, 30 were aged > 65 years (27.8%), nine had a body mass index (BMI) > 30 kg/m^2 (8.3%), 26 were smokers (24.1%), 35 were symptomatic respiratory patients at the time of surgery (32.4%), and 18 had chronic lung disease (16.7%). Sixty-eight patients (63%) underwent thoracic surgery. The mean predicted value for MIP in the preoperative period was 62.2 ± 23.1, while MEP and PEF were 71.5 ± 25.8, and 61.3 ± 24.5, respectively. Regarding the risk of PPC, 43 patients (39.8%) were classified as LR, 51 as MR, and 14 as HR (13%) (Table 2).

Table 3 shows the relationship of the CPPs in patients according to the number of diagnoses. The most common event was the acute respiratory infection followed by tracheobronchitis occurring in 29 patients (29/108; 26.9 %).

Although the CPPs was observed in 40 patients (40/108; 37%), of the patients classified as HR (14/108; 13.0%), 57.1% had CPPs ($p = 0.000$), and 71.4% died ($p = 0.001$) (Table 4).

There was a statistically significant correlation between the risk classification and PPC in the patients under study ($p = 0.000$). However, Table 5 shows that only the parameters surgical site, chronic lung disease ($p = 0.020$), % PEF < 50% ($p = 0.000$), and (% MIP + % MEP) / 2 < 75% ($p = 0.000$) were significant in relation to PPC (Table 5).

Table 2 - Characteristics of the patients (n=108)

Characteristics	Results	p
Age (years) *(mean ± SD)*	56.2 ± 14.0	0.997
(Range)	(19 – 82)	
Age over 65 years – *n (%)*		
Yes	30 (27.8)	0.000
No	78 (72.2)	
Gender - n (%)		
male	55 (50.9)	1.000
female	53 (49.1)	
BMI (Kg/m^2) - *(mean ± SD)*	26.5 ± 7.2	0.081
(Range)	(18 – 61)	
BMI above 30Kg/m^2		
Yes	09 (8.3)	0.000
No	99 (91.7)	
Current smoker - *n (%)*		
Yes	26 (24.1)	0.000
No	82 (75.9)	
Respiratory symptoms (preop) (cough / expectoration) – *n (%)*		
Yes	35 (32.4)	0.000
No	73 (67.6)	
Previous lung disease (preop*) – n (%)*		
Yes	18 (16.7)	0.000
No	90 (83.3)	
Surgical site – *n (%)*		
thoracic	68 (63.0)	0.000
upper abdominal	20 (18.5)	
other	20 (18.5)	
% of the predicted maximal inspiratory pressure (MIP) (preop) - (mean ± SD)	62.2 ± 23.1	0.000
% of the predicted maximal expiratory pressure (MEP) (preop) - (mean ± SD)	71.5 ± 25.8	0.000
% of the predicted peak expiratory flow (PEF) (preop) - (mean ± SD)	61.3 ± 24.5	0.000
% of the predicted peak expiratory flow (PEF) (preop)> 50%		
Yes	39 (36.1)	<0.001
No	69 (63.9)	
Risk of PPC		
low	43 (39.8)	0.004
moderate	51 (47.2)	
high	14 (13.0)	

Note: SD: standard deviation; DI: interquartile range; Preop: preoperative; PO: postoperative; PPC: postoperative pulmonary complications.
Source: Research data.

Table 3 - Distribution of PPCs observed while monitoring of patients

Type of PPC	Number of patients (%)
Acute respiratory infection and tracheobronchitis	29 (26.9)
Bronchospasm	13 (12.0)
Acute respiratory failure	09 (8.3)
Reintubation	08 (7.4)
Atelectasis	04 (3.7)
Prolonged mechanical ventilation (> 48 hours)	04 (3.7)

Source: Research data.

Table 4 - Distribution of patients (n = 108) with respect to the risk of PPC and the occurrence of death and hospital discharge

	Risk of PPC N (%)				
	Low (LR) N=43 (39.8)	Moderate (MR) N=51 (47.2)	High (HR) N=14 (13.0)	Total N=108 (100.0)	p
PPC					
Yes	07 (16.3)	25 (49.0)	08 (57.1)	40 (37.0)	0.000
No	36 (83.7)	26 (51.0)	06 (42.9)	68 (63.0)	
Occurrence					
High	43 (100.0)	46 (90.2)	10 (71.4)	99 (91.7)	0.001
Death	00 (0.0)	05 (9.8)	04 (28.6)	09 (8.3)	

Note: PPC: postoperative pulmonary complications.
Source: Research data.

Table 5 - Distribution of PPC with respect to the items evaluated on the scale proposed

(To be continued)

	Pulmonary complications		
Variables	Yes (n=40)	No (n=68)	p
Age over 65 years	13 (32.5)	17 (25.0)	0.405 [c]
Overweight (BMI above 30)	06 (15.0)	04 (5.9)	0.117 [c]
Surgical site			
Thoracic	25 (62.5)	43 (63.2)	
Upper abdominal	12 (30.0)	08 (11.8)	0.000 [c]
Peripheral	03 (7.5)	17 (25.0)	
Current smoker	06 (15.0)	20 (29.40)	0.092 [c]
Cough / expectoration	13 (32.5)	22 (32.4)	0.998 [c]
Previous lung disease	11 (27.5)	07 (10.3)	0.020 [c]
PEF <50% predicted	23 (57.5)	16 (23.5)	0.000 [c]

Table 5 - Distribution of PPC with respect to the items evaluated on the scale proposed

(Conclusion)

Variables	Pulmonary complications		
	Yes (n=40)	No (n=68)	p
Mean respiratory muscle strength			
(% MIP + % MEP)/2 (% predicted value)			
> 75%	05 (12.5)	41 (60.3)	0.000 [c]
65 to 74.9	00 (0.0)	03 (4.4)	
40 to 64.9	26 (65.0)	20 (29.4)	
< 39.9	09 (22.5)	04 (5.9)	
Risk of PPC			
Low	07 (17.5)	36 (52.9)	0.001 [c]
Moderate	25 (62.5)	26 (38.2)	
High	08 (20.0)	06 (8.8)	
Occurrence			
High	31 (77.5)	68 (100.0)	0.000 [c]
Death	09 (22.5)	00 (0.0)	

Note: [c]: Spearman correlation.
Source: Research data.

Discussion

Respiratory muscle dysfunction has been shown as an impact factor in the evolution of various clinical situations and surgical conditions (10, 20). Therefore, the main issue and goal of the present study was to evaluate whether the mean predicted value in respiratory muscle strength (% MIP + % MEP)/2 and the peak expiratory flow (% PEF) could replace spirometry, stratifying the surgical risk in our population.

The incidence of PPC found in our sample was 37.0%. This value is close to the mean found in other studies, whose values were around 30.0% (21, 22). However, this difference may be due to the previous studies considered PPC only the situations leading to clinical manifestations such as pneumonia and acute respiratory failure, by increasing morbidity and postoperative mortality. However, it is known that any pulmonary complications should be considered important since often there is a connection between them, given that patients who develop acute respiratory failure initially present tracheobronchitis or atelectasis.

The overall mortality rate in our study was 8.3%. This value is above that found in other studies (23, 24). This may be due to 63.0% patients underwent thoracic surgery, which increases the risk of morbidity and postoperative mortality (25). The cases of death were considered PPCs as they occurred due to pulmonary complications, which are in agreement with others authors (2, 10).

Age above 65 years was not significantly correlated with PPC. In agreement with this result, other authors (26) concluded that advanced age alone was not a risk factor for the increased PPC rate, once mortality and morbidity were more associated to the effects of aging on lung function, such as decreased lung elasticity, compliance and volumes, reduced arterial oxygen pressure (PaO_2), reduced upper airway reflexes, and patient's clinical condition than the chronological age.

In recent decades, obesity, defined as BMI ≥ 30 kg/m^2 has grown in epidemic form in modern society. Obese individuals are susceptible to ineffective cough, atelectasis at the lung bases, and progressive hypoxemia, allowing installation of secretions and infections (27). In our study, obesity alone did not correlate with PPC, disagreeing with the results of previous studies. However, recently, the impact of obesity was assessed in a large cut to evaluate patients undergoing coronary intervention, and the findings showed that BMI ≥ 30 kg/m^2 did not influence the rate of adverse clinical events (28, 29).

Patients with chronic respiratory disease and referring cough, phlegm and wheezing in the preoperative period have greater chance to develop PPC (4). In our study, despite no correlation was observed for cough and expectoration and PPC, chronic pulmonary disease had an important effect on the results. One explanation may be that, in data collection, data analysis overlapped when it was not possible to obtain information on the diagnosis of chronic lung disease, thus the diagnosis may have been replaced by the symptoms.

Smoking is a risk factor for the development of PPC, even those without lung disease (26). However, individual analysis found no significant correlation with PPC, probably due to 75.9% patients were nonsmokers.

Individual analysis of the predicted value of the maximal respiratory pressures (% MIP + % MEP)/ 2) stood out for the significant different correlation with PPC or death, which was also reported by other studies (10, 16). These authors also observed that the MIP alone allowed to associate the preoperative inspiratory dysfunction to CPP (10). However, this finding is controversial to the results found by other authors, who studied 117 patients aimed at developing a scale of PPC risk for coronary artery bypass surgery, and found MEP ≥ 75% of the predicted value, and inspiratory vital capacity ≥ 76% of the predicted value, which were considered as protective factors for the development of PPC (11). This may justify the aim of our study in drawing attention the mean values of both measurements to find the balance between % MIP and % MEP as the mean ≥ 75% a protective factor for PPC.

The PEF is a simple, fast and inexpensive methodology to assess lung function. Their values are influenced by age, sex, body weight and respiratory muscle strength, and have shown a positive correlation between vital capacity and forced expiratory volume in one second (FEV_1) (17). However, PEF does not allow differentiating between restrictive and obstructive ventilatory changes, but the decrease in FEV_1 and PEF occurs in both changes, thus providing a good correlation between the measurements (30). In our study, the % PEF < 50% of the predicted value had a statistical correlation with PPC. This can justify the importance of the association of % PEF based on the predicted value as a component of the risk scale of PPC.

The scores assigned to each of the variables for the proposed scale was based on the Torrington and Henderson scoring system (4), which were established empirically without statistical basis. In our study, the vast majority of patients (63%) underwent thoracotomy. This fact may lead us to assume that the results reflect more what happens in thoracic procedures. However, considering the applicability of the scale, we observe that the type of surgical procedure and the presence of chronic lung disease contemplated three points, reaching the limit for LR. Added to the 32.4% patients with respiratory symptoms, as is common in this population, the scale gets one more point, placing it in the MR range, justifying the prevalence of the classification of our study. Some limitations were found in the present study, including the classification of diagnoses of primary diseases leading patients to the surgical procedure, especially the thoracotomy and upper abdominal surgery, once certain diseases such as cancer exposes the body to some degree of chronic inflammation with local and/or systemic consequences. Another limitation was that the high and low abdominal surgeries have not been studied separately.

Conclusion

The proposed scale allowed to adequately stratify patients at risk of PPC. The use of both the mean values of respiratory muscle strength and PEF based on the predicted values can be globalized and easily applied, making spirometry unnecessary. These results may guide health professionals working with risk assessment for PPCs. In addition, they could allow standardization of procedures and comparison of results between services with the same profile.

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